Table 1. Effect of application method on ^{22}Na content of needles, stems and roots of American arborvitae and white spruce.

Method of application	Tissue	Counts per 10 sec/ 0.5 g dry tissue	
		Arborvitae	Spruce
Foliar	Needles	16405[z]	2647a
	Stems	1080c	1491b
	Roots	622d	268ef
Soil	Needles	121f	197f
	Stems	121f	172f
	Roots	563de	259ef

[z]Means separation by Duncan's multiple range test, 5% level.

ciated with this application method.

These results support the findings of Langille (6) that due to a combination of its protective scale-like leaves and shoot cuticular waxes, arborvitae is more resistant to salt damage than spruce. Since no determinations of leaf area were made in this study, some of the differences noted in ^{22}Na content between species may have been related to differences in absorptive surface area. Others (7), however, have suggested that arborvitae is somewhat more salt tolerant than spruce.

This thesis was further supported when application date was considered (Table 2). Unlike arborvitae, in which ^{22}Na content was not influenced by date on which foliar application occurred, spruce showed a significant

Table 2. Effect of method and date of application on ^{22}Na content of American arborvitae and white spruce.

Method of application	Application date	Counts per 10 sec/ 0.5 g dry tissue	
		Arborvitae	Spruce
Foliar	Feb. 16	1161cd[z]	811d
	Feb. 23	917cd	1396bc
	Mar. 2	1122cd	1350bc
	Mar. 9	1423bc	1358bc
	Mar. 20	950cd	2151a
	Mar. 27	1111cd	1747ab
Soil	Feb. 16	338e	252e
	Feb. 23	167e	207e
	Mar. 2	296e	246e
	Mar. 9	361e	236e
	Mar. 20	234e	109e
	Mar. 27	213e	206e

[z]Means separation by Duncan's multiple range test, 5% level.

increase in foliar absorption of ^{22}Na as spring approached. Other workers (7) reported that coniferous species exposed to aerial salt drift were damaged in late winter. For the soil application method, however, application date had no effect on ^{22}Na content in either species.

Results of this study support the case for salt damage due to foliar absorption (1, 3, 7) and confirm that aerial-application results in higher foliar Na than soil-application (1). Furthermore, late winter salt applications for deicing purposes may lead to an early decline in susceptible species.

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Pathogenicity, Characteristics, and Host Range of the Fungus, *Pythium irregulare* Buis. in a Container Nursery in Southern California[1]

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Abstract. Pythium irregulare **was isolated from roots and found to be pathogenic to 4 different hosts showing various disease syndromes in one southern California nursery. The hosts were** *Dizygotheca elegantissima* **Vignier & Guill.,** *Brassaia actinophylla* **Endl.** *Ilex cornuta* **Lindl. & Paxt. cv. Rotunda and** *Nerium oleander* **Linn. cv. Petite Salmon. One isolate was more damaging on** *D. elegantissima* **growing at a mean temperature of 15.5°C than at a mean temperature of 23°C. A bioassay proved that** *P. irregulare* **was an inhabitant of the soil at the site of the nursery.**

In southern California, root rots are a common problem affecting many species of woody plants in production nurseries. Mature plants as well as seedlings and rooted cuttings are affected. Mature plants usually manifest various degrees of root necrosis, poor new root development, reduced growth, leaf chlorosis and defoliation, whereas seedlings may be killed from either a pre-emergence or post-emergence damping-off. During 2 successive years, species of woody ornamental plants which exhibited typical symptoms of root rot in a large production nursery were studied. Of the many organisms isolated from affected roots, the water mold, *Pythium irregulare*, was recovered in 8 different cases and was proved pathogenic in 4 of those cases.

P. irregulare has been found in many soils throughout the U.S. (5) and has been reported to attack a wide range of food and forage crops such as alfalfa and clover in Wisconsin (3), peach trees in Georgia (6), corn in Wisconsin (7), and small grains in the northern great plains (12). It also has been reported associated with root disorders on ornamentals in Georgia (4) and on *Gerbera* in California (10). It has not, however, been previously reported to be the causal organism of root rot of the 4 hosts described in this paper, nor has it been previously reported to be pathogenic on several different ornamental species at a single location.

Hosts. Young *Brassaia actinophylla* (Schefflera) plants which had been transplanted at the nursery into half-liter

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containers failed to develop uniformly. Some had reached a height of 30–40 cm while others had grown very little from their original sizes (15–20 cm) and appeared weak with a light chlorotic mottling of the leaves. A few plants had died. Roots of affected plants showed considerable necrosis and very little new growth. When Schefflera seedlings were tested in the greenhouse in a planting medium artificially infested with the isolate of *P. irregulare* from Schefflera, the symptoms of root rot infection were identical to those observed in the nursery.

Nerium oleander cv. Petite Salmon plants growing in 4-liter containers on the ground outdoors appeared unhealthy and were not as large as apparently healthy plants. Shoot growth lacked vigor, leaves varied in degree of chlorosis, moderate defoliation had occurred and the majority of the roots were necrotic. *P. irregulare* was isolated from necrotic root tissues. These symptoms were most pronounced in the spring, but with the warmer temperatures of summer, there was a remission of symptoms on many of the plants.

Dizygotheca elegantissima seedlings failed to emerge or died after emergence in flats placed on benches in a propagation house. Each flat contained 2500 seeds and the pattern of seedling loss, which was estimated to be about half of the population of each flat, was typical of the radial growth of fungal colonies. The pattern of spread suggested that there were two or three loci of initial infection. *P. irregulare* was isolated from necrotic root and hypocotyl tissues.

Ilex cornuta cv. Rotunda plants were in 4-liter plastic pots. They had stopped growing. Defoliation was from moderate to severe. There was very little chlorosis, but the majority of the fallen leaves and some leaves on the plants were partly necrotic with many minute, black spots. The spots were found to be fructifications of a species of *Colletotrichum* which is a fungal genus containing many pathogenic species. *Colletotrichum* was suspected as the cause, but extensive pathogenicity tests did not establish a pathogenic relationship. The roots were then studied and found heavily necrotic and colonized by *P. irregulare*.

Pathogenicity. Isolates of *P. irregulare* were proved to cause the symptoms of disease of their respective hosts. Healthy young plants were grown in a sterile planting medium into which had been incorporated a viable source of inoculum. In each case the inoculum was prepared by growing the respective isolate of *P. irregulare* on autoclaved millet seed (10) until all the seed appeared to be colonized. Reisolations from the infected roots yielded *P. irregulare*. Cultures of the causal organism were identified utilizing the keys of Middleton (9) and Waterhouse (13) and the research paper on *P. irregulare* by Biesbrock and Hendrix (2).

Temperature. Different species of *Pythium* have been shown to prefer certain temp ranges for optimum mycelial growth (9) and disease development. Maximum damping-off of red pine seedlings caused by *P. irregulare* occurred at temp below 24°C (11) and most severe stunting of peach seedlings due to *P. irregulare* occurred at 13° (1). In the case of *N. oleander*, we noted that affected plants tended to recover during summer, and that seedling death of *D. elegantissima* was greatest in winter. Therefore, we tested the possibility of temp affecting disease severity on *D. elegantissima* by growing young plants in soil infested with *P. irregulare* under 2 different temp regimes. One regime was in the greenhouse and the other in the shadehouse where the mean temp during the test averaged 23° and 15.5°, respectively. After 34 days of growth in the shadehouse, all of the inoculated plants were dead whereas only one of the inoculated test plants was dead in the greenhouse. All plants in noninfested soil remained healthy.

Inoculum source. In order to develop control measures, it is necessary to determine the source of the inoculum causing the disorders. Since Kim et al. (8) found *P. irregulare* and other plant pathogens in various peat products, we tested samples of the ingredients used by the nursery in its planting media by growing seedlings of *D. elegantissima* in them. The results were negative. Samples were then taken of the native soil on which the nursery was located near the area where the planting media were prepared. This soil was mixed with steamed amendments and planted with seedlings of *D. elegantissima*. As a control, plants were grown in field soil which had been steamed and mixed with steamed amendments. After 70 days of growth, the plants in the nonsteamed nursery soil showed typical symptoms of disease while the plants in the steamed field soil were healthy. *P. irregulare* was isolated from the roots of the plants in the nonsteamed nursery soil.

Discussion. This work has established the presence of the plant pathogen, *P. irregulare*, in the soil on which a production nursery is located and identified 4 serious diseases caused by that pathogen. It is understandable that sanitation practices are not entirely effective and that spread of inoculum is difficult to prevent because of the heavy traffic of employees and vehicles. However, early infection can be greatly reduced by constant attention to cleanliness of materials, facilities, equipment and personnel in the propagation and potting areas. The influence of temp on the development of *P. irregulare* infected plants may be turned to the advantage of the grower by shifting either the growing period of the crop or their growing areas to reduce the severity of the disease. Since fungicides controlling *Pythium* are specific, this report also emphasizes the need to determine precisely the identity of an organism causing root rot.

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